

A Comparative study of the Continuum and Emission Characteristics of Comet Dust

I. Are the Silicates in Comet Halley and Kohoutek Amorphous or Crystalline ?

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Abstract

A continuum emission was subtracted from the $10 \mu\text{m}$ emission observed towards comets Halley and Kohoutek. The $10 \mu\text{m}$ excess emissions have been compared with BN absorption and laboratory amorphous silicates. The results show that cometary silicates are predominantly amorphous which is consistent with the interstellar dust model of comets.

1. Continuum baseline

A baseline has been calculated and a continuum emission was subsequently subtracted from the $10 \mu\text{m}$ emission features observed towards Comet Halley (Bregman et al. 1987) and Kohoutek (Merrill 1974). The IR continuum emission of a comet includes two parts: non-neutrally scattered sunlight and thermal emission.

2. $10 \mu\text{m}$ excess emission from Comets Halley and Kohoutek

The $10 \mu\text{m}$ feature of Comet Halley and Comet Kohoutek has been observed at a resolution probably sufficient to distinguish crystalline and amorphous silicates.

A comparison between the material responsible for the $10 \mu\text{m}$ feature in comets and interstellar dust may reveal something about cometary origin and evolution. Using the baseline in fig. 1 we obtain the excess emission above the $10 \mu\text{m}$ continuum observed towards Comet Halley and Kohoutek.

3. Evidence for the dominance of amorphous silicates in Comets

Figures 2, 3 and 4 show that the cometary $10 \mu\text{m}$ feature is similar to the BN object (Willner et al. 1982) which, in turn, resembles a combination of laboratory amorphous silicates (Day 1979).

The $10 \mu\text{m}$ feature of Comet Halley is distinguished by an extra $11.2 \mu\text{m}$ band which probably is produced by crystalline olivine (Sandford and Walker 1985). The question is how much crystalline olivine is present?

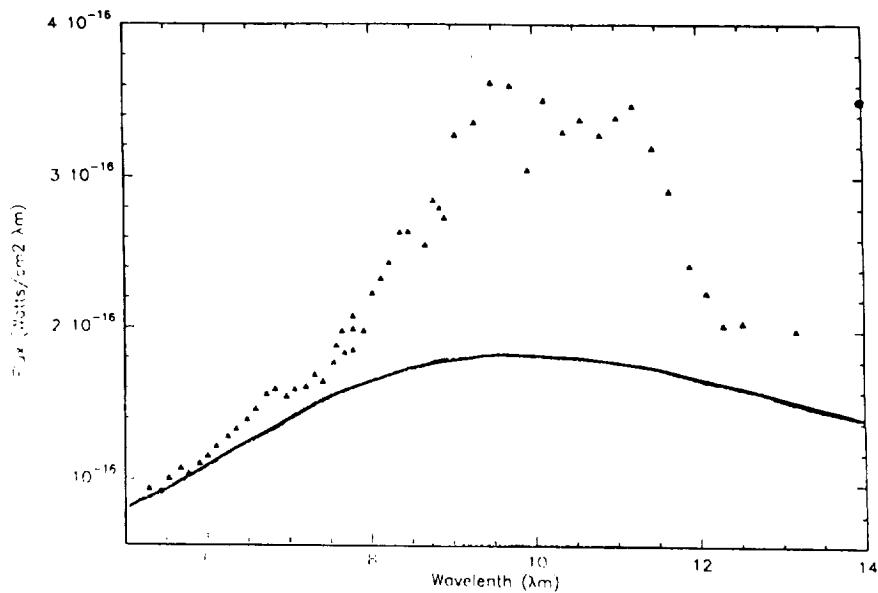


Fig. 1. Observed 10 μm emission (\blacktriangle) and base line for Comet Halley (Heliocentric distance of Comet = 1.24–1.3 A.U. $T = 290$ K. Note that the base line or continuum here is different from Bregman et al. (1987).

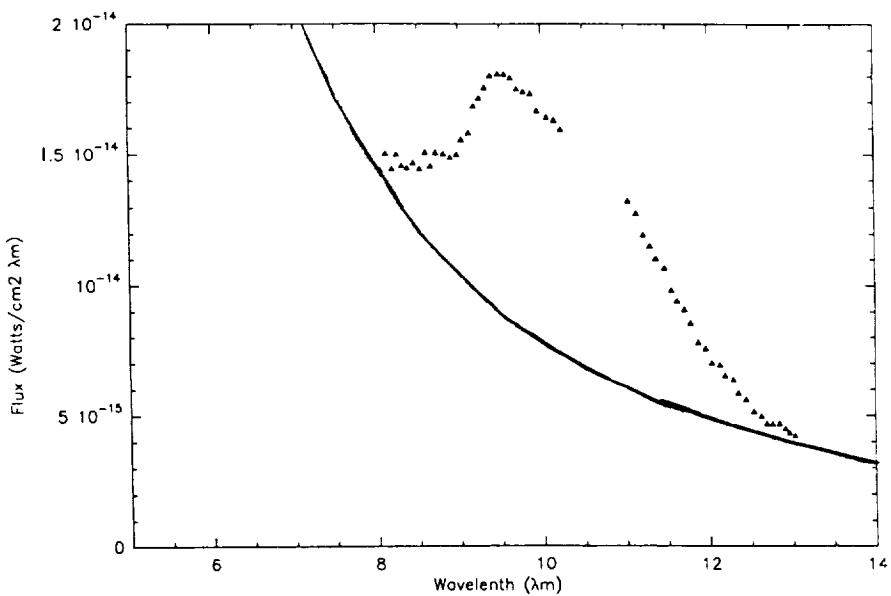


Fig. 2. Observed 10 μm emission (\blacktriangle) and base line for Comet Kohoutek (Heliocentric distance of Comet = 0.4–0.23 A.U. $T = 600$ K.

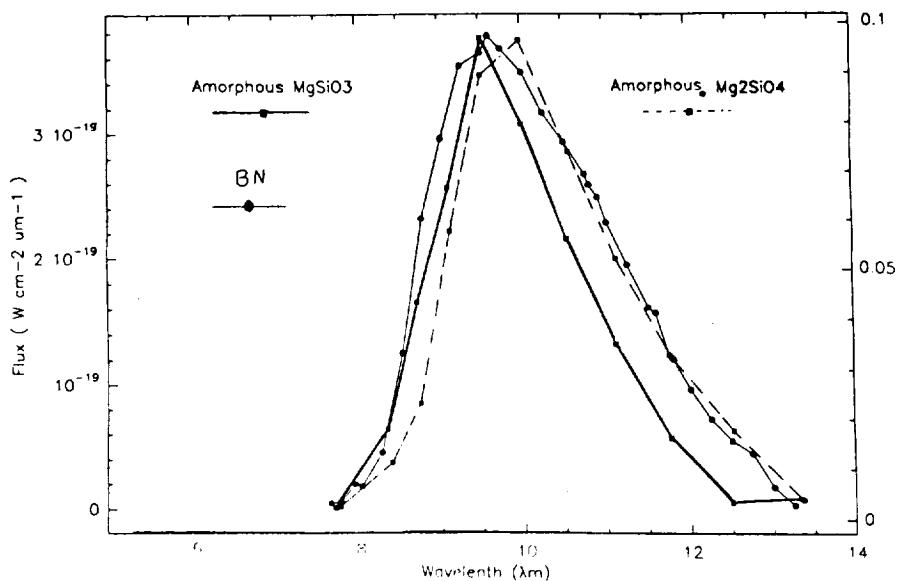


Fig. 3. Comparison of the $10 \mu\text{m}$ feature of BN and laboratory amorphous silicates.

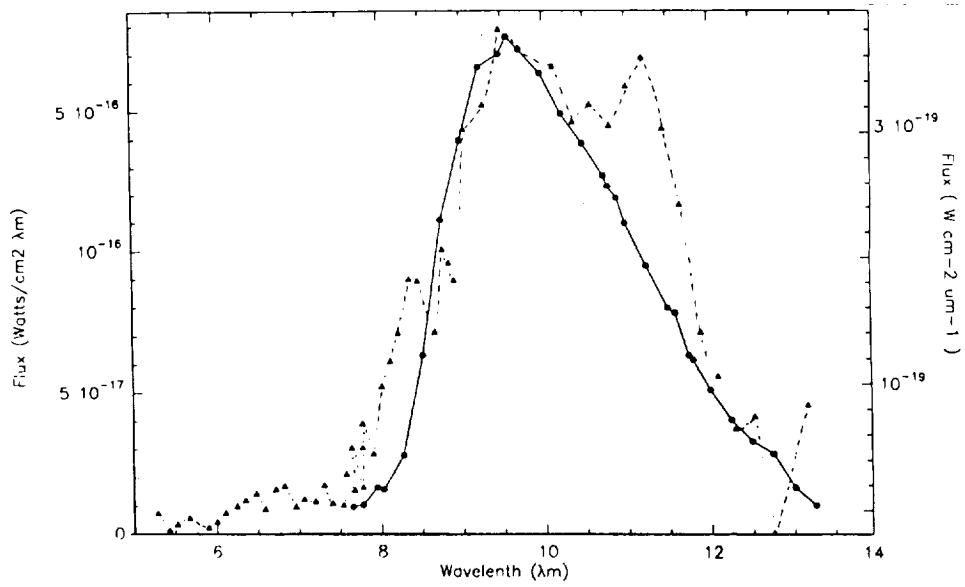


Fig. 4. Comet Halley emission (---▲---) compared with BN absorption (—●—).

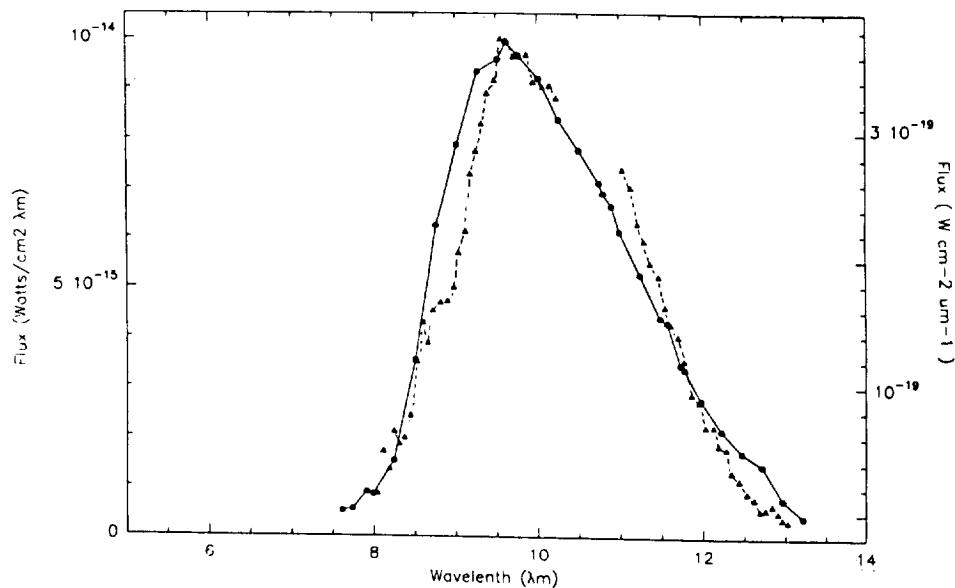


Fig. 5. Comet Kohoutek emission (---▲---) compared with BN absorption (—●—).

Since the extinction efficiency of crystalline relative to amorphous silicates is $Q_{cry} / Q_{amo} = 10$ (Day et al. 1974), the extra feature represents a small addition by mass. Subtracting the amorphous component (BN) from the total of Comet Halley, yields a peak ratio $I_{cry} / I_{amo} = 6.5 : 14$ which implies a mass ratio of crystalline to amorphous silicate = 0.05, which is indeed quite small !

4. Discussion and Conclusion

1) Cometary silicates are predominantly similar to interstellar silicates. For a periodic comet like Comet Halley, it is to be expected that some of the silicate may have been heated enough to convert to crystalline form. But apparently, this is only a small fraction of the total.

2) A comparison of Comet Halley silicates with a combination of the crystalline forms observed in IDP's seemed reasonable at first sight (Walker 1988, Brownlee 1988). But, if true, it would imply that the total silicate mass in Comet Halley dust is lower than that given by mass spectrometry data of Kissel and Krueger (1987). They estimated $m_{org} / m_{sil} = 0.5$ while using crystalline silicate to produce the $10 \mu m$ emission would give $m_{org} / m_{sil} = 5$ (Greenberg et al. 1988). This is a factor of 10 too high.

References

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